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M E M O R A N D U M
July 22, 1982

To: Fred Fenske

Through: Dick Cunningham

From: John Bernhardt JB.

Subject: U.S. Oil and Refining Company Receiving Water Survey, May 5, 1981

INTRODUCTION

Early in 1981, the Department of Ecology (WDOE) and the U.S. Environmental Protection Agency (EPA) initiated studies to identify sources of toxic pollutants found in Commencement Bay water, biota, and sediment. Six major point-source dischargers were selected for study based on proximity to the bay and consideration of the pollutants handled, namely:

1. Reichhold Chemicals, Inc.;
2. U.S. Oil and Refining Company;
3. Pennwalt Corporation;
4. Tacoma Central Sewage Treatment Plant;
5. Sound Refining; and
6. St. Regis Paper Company

The locations of these facilities are shown in Figure 1.

A standard WDOE Class II inspection/receiving water study was to be performed concurrently at each facility with one major modification -- inclusion of sampling for the EPA organic priority pollutants and certain other toxics. The results would be documented in WDOE investigative reports which, along with results from other studies, would provide government management agencies with the information needed to make the most informed decisions regarding the issue of toxics pollution in Commencement Bay. USEPA assisted in the field and provided laboratory support and quality assurance for the organic priority pollutant aspect of the studies.

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The results of the second receiving water survey performed, U.S. Oil and Refining Company, are presented in this report. Findings for the Class II inspection which accompanied this survey can be found in the following report:

> Yake, B., 1981. "U.S. Oil and Refining Co. Class II Inspection of May 5 and 6", Memorandum. State of Washington, Department of Ecology, 12 pp.

The above-cited report includes a description of the refinery's wastewater treatment system and effluent characteristics.

LOCATION AND DESCRIPTION

U.S. Oil is a small refinery which processes some 20,000 barrels (42 gallons per bbl) per day of "light" crude, primarily of Indonesian origin. Gasoline and aviation fuel are the main products although quantities of diesel, stove, and black oils also are produced. Tanker vessels deliver crude to the refinery's Blair Waterway dock twice per month. Crude is piped inland to the refinery where crude and product are stored on site in some 70 surface tanks with a 1,600,000 bbl storage capacity (DOE, 1978).

Waste- and stormwater from the refinery area are routed to a small treatment facility located on site (Figure 2). After several treatment processes are completed, the plant effluent is discharged to an underground sewer line which runs for about 0.4 mile along the northeast property line to Lincoln Drain. Lillyblad Petroleum, Inc. and possibly some other businesses also discharge to this sewer line (Yake, 1981). Since the aforementioned line carries wastewaters originating from several sources, it will be referred to as "U.S. Oil/combined discharge" throughout this report.

For clarification, the name "Lincoln Drain" applies to two small tide drains which receive runoff waters from drainages on opposite sides of Blair Waterway. Both run parallel to Lincoln Avenue which is split into north and south segments by Blair Waterway. There is no bridge. Lincoln Drain North was surveyed during an earlier investigation of Reichhold Chemical, Inc. (Bernhardt, 1982). Lincoln Drain South, which serves a lowland drainage lying between Blair Waterway and the Puyallup River, is addressed by the present survey.

Lincoln Drain South runs inland along Lincoln Avenue for about one mile to Milwaukee Way, then arcs to the south and continues for several hundred yards before dissipating along the Milwaukee-Saint Paul Railroad grade. The entire drain is sluggish and sediments have built up in many areas to the point where marsh grasses dominate some sections of the main channel. Waters back up twice a day when the tide gates are closed. The U.S. Oil/combined discharge is located 0.4 mile inland from Blair Waterway.

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METHODS

Flow was measured at three locations with a Marsh-McBirney magnetic flow meter: (1) Lincoln Drain at Blair Waterway; (2) U.S. Oil/combined discharge at Lincoln Drain; and (3) Lincoln Drain at Milwaukee Way (Figure 2).

Water quality samples were collected during May 5, 1981 at the three stations described above. Grab or composite samples were collected depending on the analyses required. The following conventional analyses were performed:

Laboratory	Field
pH (S.U.)	Temperature (°C)*
Dissolved Oxygen (mg/L)*	pH (S.U.)*
Salinity (ppt)	
Specific Conductance (µmhos/cm)	
Chemical Oxygen Demand (mg/L)	
Fecal Coliform (col/100 ml)*	
Nitrate-N (mg/L)	
Nitrite-N (mg/L)	
Ammonia-N (mg/L)	
Orthophosphate-P (mg/L)	
Total Phosphate-P (mg/L)	
Total Solids (mg/L)	
Total Non-volatile Solids (mg/L)	
Total Suspended Solids (mg/L)	
Total Non-volatile Suspended Solids (mg/L)	
Residual Phenolics as Phenol (mg/L)*	
Residual Oil and Grease (mg/L)*	

*Grab samples are designated by an asterisk.

An additional grab sample was collected from a pipe which drains a portion of the Murray-Pacific log sort yard (Figure 2). This sample was analyzed for a limited number of parameters.

Water samples collected at the three primary stations were analyzed for organics and metals included in the USEPA list of priority pollutants. Selected other toxic pollutants were also included in the analysis.

For the toxics sampling, a specially cleaned Manning composite sampler was installed at each station and set to draw 250 ml of sample every 15 minutes. Since Lincoln Drain South backs up during flood tide, sampling was performed during low tide, free-flowing conditions to minimize this influence. The compositors were activated about two hours before low slack and operated for four hours.

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The samples were forwarded to three analytical laboratories, depending on the tests needed: (1) USEPA contract laboratory, California Analytical Laboratories, Inc. - organic priority pollutants and other selected organics; (2) USEPA Manchester laboratory - cyanide; and (3) WDOE Tumwater laboratory - conventional parameters, phenol, and metals (except mercury - Redmond laboratory).

The USEPA quality assurance procedure for toxics sampling involved four steps: (1) Laboratory Blank - The Manchester laboratory prepared a sample of water (organic-free passed through activated charcoal filter) and retained it at the laboratory; (2) Transport Blank - Field sampling personnel were required to carry a vial of laboratory water while sampling, but not open it; (3) Transfer Blank - Field sampling personnel carried a second vial of which the contents were transferred to another second vial at the time of sample collection; and (4) Field Blank - Laboratory water was flushed through the composite sampler just prior to sampling, and retained. Sampling results were accepted or rejected based on a check against these four control samples.

Standard analytical procedures for water quality samples were employed at the Department of Ecology laboratory. All analyses were performed according to Standard Methods (APHA, AWWA, and WACF, 1976) or USEPA Methods (USEPA, 1979).

Bottom sediments were obtained at the three main water quality sampling stations and analyzed for selected metals at the WDOE laboratory. At each station, 10 subsamples of surface sediments (top 2 cm) were collected with a small scoop and composited into a single sample. An additional sediment sample was collected at the mouth of Lincoln Drain and analyzed for organic toxics.

As part of the survey, limited biological sampling was performed on May 6, 1981 near the mouth of Lincoln Drain. The edible mussel, *Mytilus edulis*, a filter feeder, was collected from the bay side of the tide gate and analyzed for tissue metals. Fifty organisms were obtained, transported to the WDOE laboratory, and homogenized to provide the five grams required for analysis. The organisms ranged from 33 to 55 mm in length.

In addition, during July 30, 1981, WDOE and USEPA collected intertidal and deepwater sediment samples at a number of locations in Commencement Bay as part of another toxics investigation relating to these waters (Swartz, *et al.*, 1982). Four or five samples of surface sediments to a depth of 2 cm were collected along a transect at each intertidal sampling site. Amphipod bioassays (*Rhepoxynius abronius*) were performed at the federal Marine Science Center in Newport, Oregon. One sample was collected in the vicinity of the Lincoln Drain South tide gate.

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RESULTS

Five areas are addressed: (1) Effluent Dilution; (2) Water Quality Sampling; (3) Bottom Sediment; (4) Mussel Tissue; and (5) Sediment Bioassay.

1. Effluent Dilution

Flow measurements obtained during the survey are given below:

Lincoln Drain at Milwaukee Way	1.013 cfs
U.S. Oil Treatment Facility Discharge	.230*
U.S. Oil/Combined Discharge at Lincoln Drain	.577
Lincoln Drain at Mouth	1.359

*Determined during Class II Inspection.

U.S. Oil's discharge is relatively small and becomes mixed with waters from several other sources before reaching Blair Waterway. Initially, in the underground sewer line the discharge combines with an approximately equal quantity of wastewaters from Lillyblad Petroleum, Inc. and possibly other sources (Yake, 1981). Upon entering the drain, waters from the upper drainage and some other small inputs provide additional dilution. Considering all sources, U.S. Oil accounted for about one-fifth (17 percent) of the discharge to Blair Waterway, at the time of the survey.

2. Water Quality Sampling

A. Conventional Parameters

Sampling results for the three field and 18 laboratory tests performed by WDOE are presented in Table 1. Noteworthy findings were:

(1) The tide gate at Blair Waterway was functioning properly. Samples collected immediately "upstream" of the gate contained 1,288 µmhos/cm specific conductivity and 0.8 ppt salinity, far below those observed in an earlier study of Lincoln Drain North which discharges to the opposite side of Blair Waterway. This drain had a malfunctioning tide gate resulting in about 13,000 µmhos/cm specific conductivity and 10 ppt salinity in the drain above (Bernhardt, 1982).

(2) Ammonia-nitrogen levels in Lincoln Drain were somewhat higher than "clean" waters which generally fall below 0.2 mg/L. This would be expected in a lowland drainage ditch where organic matter from various sources (grasses, etc.) may settle and decompose.

B. Organic Priority Pollutants

Low levels of 13 priority pollutants, mainly volatiles, were detected in Lincoln Avenue Drain (including the U.S. Oil/ combined discharge) during the May 5 sampling. All concentrations were well within the USEPA ambient water quality criteria for the protection of aquatic organisms (Tables 2 and 3). Three additional compounds were tentatively identified but not quantified.

Most of the compounds observed appeared to be originating from the U.S. Oil/combined discharge where the following 13 pollutants were detected:

Acid	Base-Neutral	Volatile	Pesticide	Tentatively Identified
Penta-chloro-phenol*	1,4-Dichloro-benzene* Napthalene	Chloroform* Methylene Chloride* 1,1-Dichloroethane* 1,1,1-Trichloro-ethane* 1,2-Trans-Dichloro-ethylene* Tetrachloroethylene Chlorobenzene	Aldrin*	2-Ethyl Hexanoic acid 1H-Indene

None of these compounds were detected during the Class II facility inspection at U.S. Oil. An investigation by the WDOE Southwest Regional Office revealed that Lillyblad Petroleum, Inc. and possibly others which also discharge to the sewer line were the probable source (Monahan, 1982). Eight of the compounds (denoted by an asterisk) also were observed at the mouth of Lincoln Drain. Concentrations for the most part were lower than in U.S. Oil/combined discharge, an expected result considering dilution.

Low levels of three compounds were observed at the Milwaukee Way station above U.S. Oil: pentachlorophenol; chloroform; and methylene chloride. Pentachlorophenol is a commercially produced bactericide, fungicide, and slimicide used primarily for preserving wood, wood products, and other materials (USEPA, 1980). Trace amounts of chloroform occur in the environment largely from chlorination of water and wastewater (USEPA, 1980). Methylene chloride, the third organic observed, appeared for the most part, to be a contaminant introduced to the samples as a sample bottle cleaning residual.

Toxics sampling data collected by USEPA from Lincoln Drain during two previous surveys, June and September 1980, were reviewed and compared with the present survey.

The results for the USEPA data were similar to the present effort in that a number of volatile organics were observed at the mouth of the drain. Trace amounts of some pesticides also were detected at this site while low levels of napthalene, pyrene, and other base-neutral compounds were observed in the upper drainage (Table 2).

Compounds observed during more than one sampling may suggest something more than intermittent source. Compounds which fall into this category for Lincoln Drain at the mouth are listed below:

Compound	USEPA 6/3/80	USEPA 9/24/80	WDOE 5/5/81
1,2-Dichlorobenzene		X	X
Chloroform**	X	X	X
Methylene Chloride**	X		X
1,1-Dichloroethane*		X	X
1,1,1-Trichloroethane*	X	X	X
1,2-Trans-Dichloroethylene*		X	X
Trichloroethane	X	X	
Tetrachloroethylene*	X	X	X

Six compounds (* and **) were detected in the U.S. Oil/combined discharge and two also at Milwaukee Way (**) above this input, during the May 5, 1981 sampling. As previously stated, all concentrations were substantially below the USEPA water quality criteria in each case. These criteria do not consider cumulative, synergistic, or antagonistic effects.

C. Trace Metals

Generally low levels of trace metals were observed at all three stations sampled in Lincoln Drain during the present survey. These findings contrasted with the USEPA 1980 historical data for the same drainage ditch which indicated elevated concentrations of some heavy metals including lead, copper, arsenic, zinc, and mercury (Table 2).

3. Bottom Sediment

Six priority pollutants were observed in the sample collected near the mouth of Lincoln Drain South (Table 2). Two of these, the 1,2- and 1,4-dichlorobenzene (DCB) isomers, also were observed in the

water sample collected at this station while 1,4-DCB was detected in the U.S. Oil/combined discharge to Lincoln Drain. 1,2-DCB is used as a process solvent and in the synthesis of dye stuffs, degreasers, and herbicides (USEPA, 1980). 1,4-DCB is used primarily as an insecticide and air deodorant (toilet bars, etc.) which accounts for 90 percent of production (ibid). The sediment concentrations of both compounds appeared to be low if USEPA water quality criteria are used as a general guide (Tables 2 and 3). A review of priority pollutant analyses performed in freshwaters statewide during 1979-1980 showed no DCBs in the 35 samples collected (USEPA unpublished data, 1981).

The concentration of bis(2-ethylhexyl)phthalate (DEHP) observed at the mouth of the drain, at 9,900, was very high. DEHP is one of a group of plasticizers, the phthalated esters, which are interfused with various polymers to increase flexibility, extensibility, and workability (White and Robbins, 1974). These substances are considered ubiquitous in modern society, being present in foil wraps, tubing, clothing, upholstery, and almost anything else involving plastics.

DEHP in the environment is readily adsorbed onto suspended particulates, complexes with humic substances, and to some extent, is taken up by organisms (USEPA, 1980).

Priority pollutant analyses performed statewide by USEPA during 1979 and 1980 (USEPA unpublished data, 1981) and sediment data collected during the other WDOE Class II inspections/receiving water surveys in Commencement Bay were reviewed in an effort to put the DEHP findings for the present effort into perspective. DEHP was detected in four of 15 sediment samples collected in the bay and analyzed for organic pollutants:

Location	DEHP (µg/Kg, dry weight
Sound Refining study, Hylebos Waterway off west end of property	620
Reichhold Chemicals, Inc. survey, embayment at mouth of Lincoln Avenue Drain, north shore	5675
Reichhold Chemicals, Inc. survey, Blair Waterway off mouth of Lincoln Avenue Drain, north shore	1449
U.S. Oil and Refining Co. survey, Blair Waterway off mouth of Lincoln Avenue Drain, south shore	9900

For the 1979-1980 USEPA statewide sampling of freshwaters, DEHP was detected in 22 of 35 bottom sediment samples collected:

Location	DEHP (µg/Kg, dry weight)
Duwamish River below Renton	200
Naches River at mouth	200
Spokane River at Spokane STP outfall	100
Cedar River near Landsburg	80
Spokane River 1.5 miles below Spokane STP	70
Spokane River 0.5 mile below Spokane STP	54
Spokane River at Spokane STP outfall	53
Five sites	0.3 to 52
Ten sites	0.02 to 0.29
Thirteen sites	none detected

DEHP levels in Lincoln Drain below U.S. Oil and Refining Company were the highest sediment DEHP levels of areas thus far sampled in Commencement Bay as part of the overall WDOE investigation which includes six facilities. As stated in the Reichhold Chemicals, Inc. receiving water study (Bernhardt, 1982), these results suggest a significant source in or near Blair Waterway.

As previously noted with the water quality samples, methylene chloride observed in the bottom sediments may be, at least in part, attributed to the sample bottle cleaning process (Table 2).

The two remaining compounds, hexadecanoic acid and tetradecanoic acid, were tentatively identified but not quantified. Both are organic (fatty) acids which occur naturally as glycerol esters in fats and oils and considered ubiquitous in nature at low levels.

Since Lincoln Drain South is tidally influenced, the sediment metals data were compared with data collected from both freshwater and estuarine areas of Commencement Bay as well as the state in general (Table 4). Sediments collected near the U.S. Oil/combined outfall contained generally low or moderate levels of the eight heavy metals included in the analysis. There appeared to be a significant source at the upper end of Lincoln Drain judging from the Milwaukee Road station results.

4. Mussel Tissue

Edible bay mussels (*Mytilus edulis*) gathered from the bay side of the Lincoln Drain South tide gate contained metals at concentrations comparable to those previously sampled in the embayment (Lincoln Drain North) on the opposite side of Blair Waterway (Table 5). Exceptions were nickel, arsenic, and mercury which were

somewhat higher in the embayment. Mussels at both sites are affected by lowland drainage. Cadmium in these two samples was lower than either the background (BWMP) stations or stations near ASARCO. The remaining metals in Lincoln Drain South, for the most part, had concentrations higher than background but lower than near ASARCO.

5. Sediment Bioassay

Six of 20 infaunal amphipods (*Rhepoxynius abronius*) seeded to the surface sediment sample collected from the intertidal area near the mouth of Lincoln Drain South survived for 96 hours (Swatrz, 1981). Swartz divides sediment toxicity into four classes based on the frequency distribution of samples collected in Yaquina and Commencement bays:

(1) 15-20 survivors - a relatively high survival within the expected control range;

(2) 8-14 survivors - moderate survival, below the usual control range;

(3) 1-7 survivors - low survival, well below the control; and

(4) 0 survivors - very toxic conditions.

A single "low survival" sample is of limited value unless it can be correlated with an unfavorable condition and confirmation tests are performed. Swartz (1981) collected sediments for chemical analysis as part of the bioassay sampling; however, the analytical results are not available as of this writing.

DISCUSSION

Lincoln Drain South, like its counterpart which discharges to Blair Waterway on the opposite shore, is of marginal value as habitat for aquatic life, being used almost exclusively as an avenue by which surface runoff and discharge waters reach Blair Waterway. Pollutant loading to the waterway which supports a significant assemblage of biota and recreational uses as well as other benefits, is the main concern. Loadings based on the conditions that existed on May 5, 1981 (low flow) are shown in Table 6 for the toxic constituents observed.

Oil and grease was the main constituent loaded to Blair Waterway at the time of the survey with most (13 lbs/day) originating from U.S. Oil. U.S. Oil's NPDES permit limitation allows for an average of 30 lbs/day and 55 lbs/day maximum for this constituent. Low loadings were observed for the remaining compounds.

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Wastewaters generated by U.S. Oil and Refining Company did not appear to have a discernible impact on Blair Waterway at the time of the survey documented in this report. Other sources within the south Lincoln Avenue drainage were of greater consequence although the impact was minimal overall. However, one set of data suggests the possibility of biological communities being stressed in the waterway off both Lincoln Drain outfalls where Swartz (1981) observed relatively high amphipod mortalities. Whether or not a significant problem exists in this area needs confirmation.

JB:cp

Attachments

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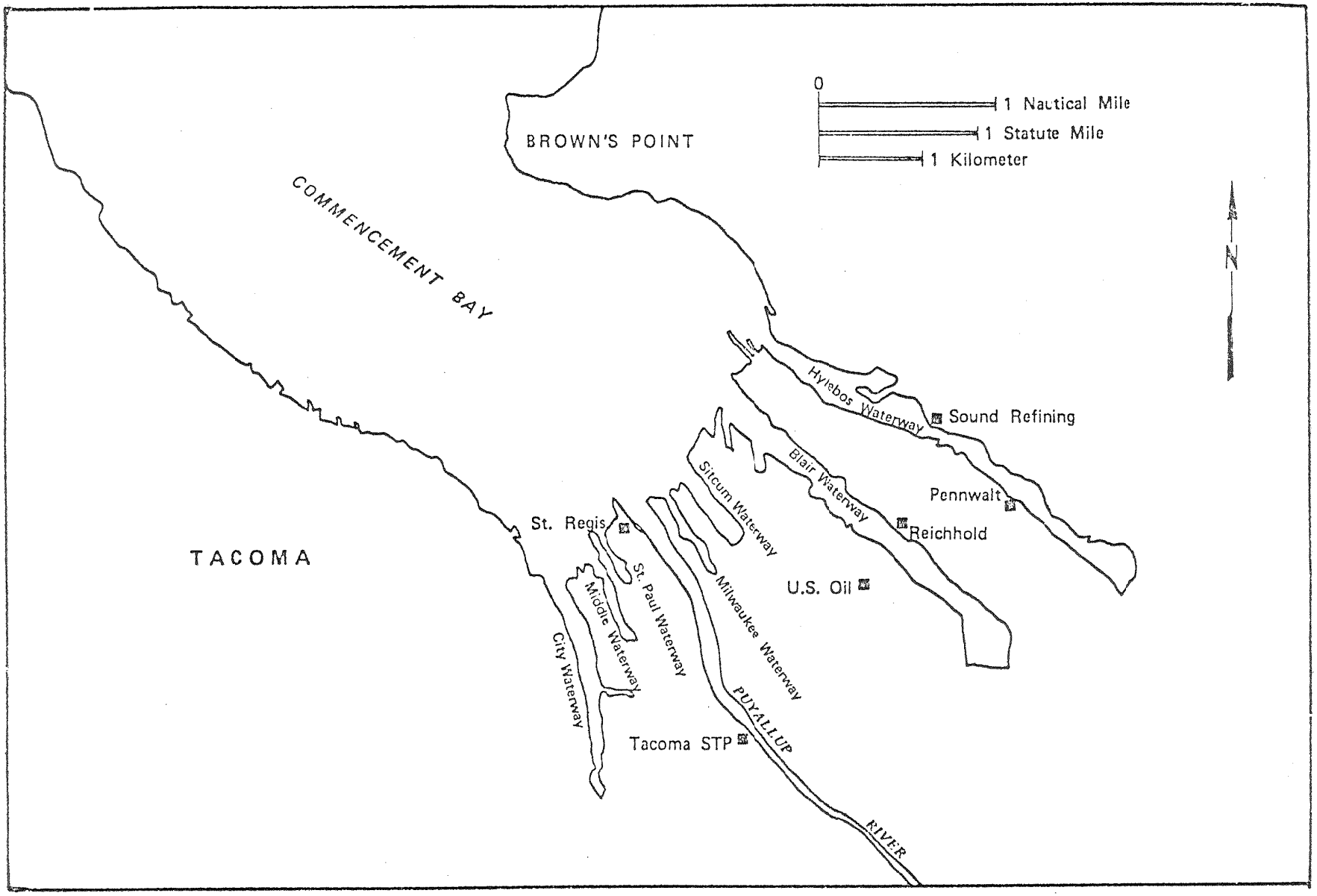

FIGURE 1. Map depicting locations of industries investigated as part of WDOE assessment of toxics pollution in Commencement Bay, during summer 1981.

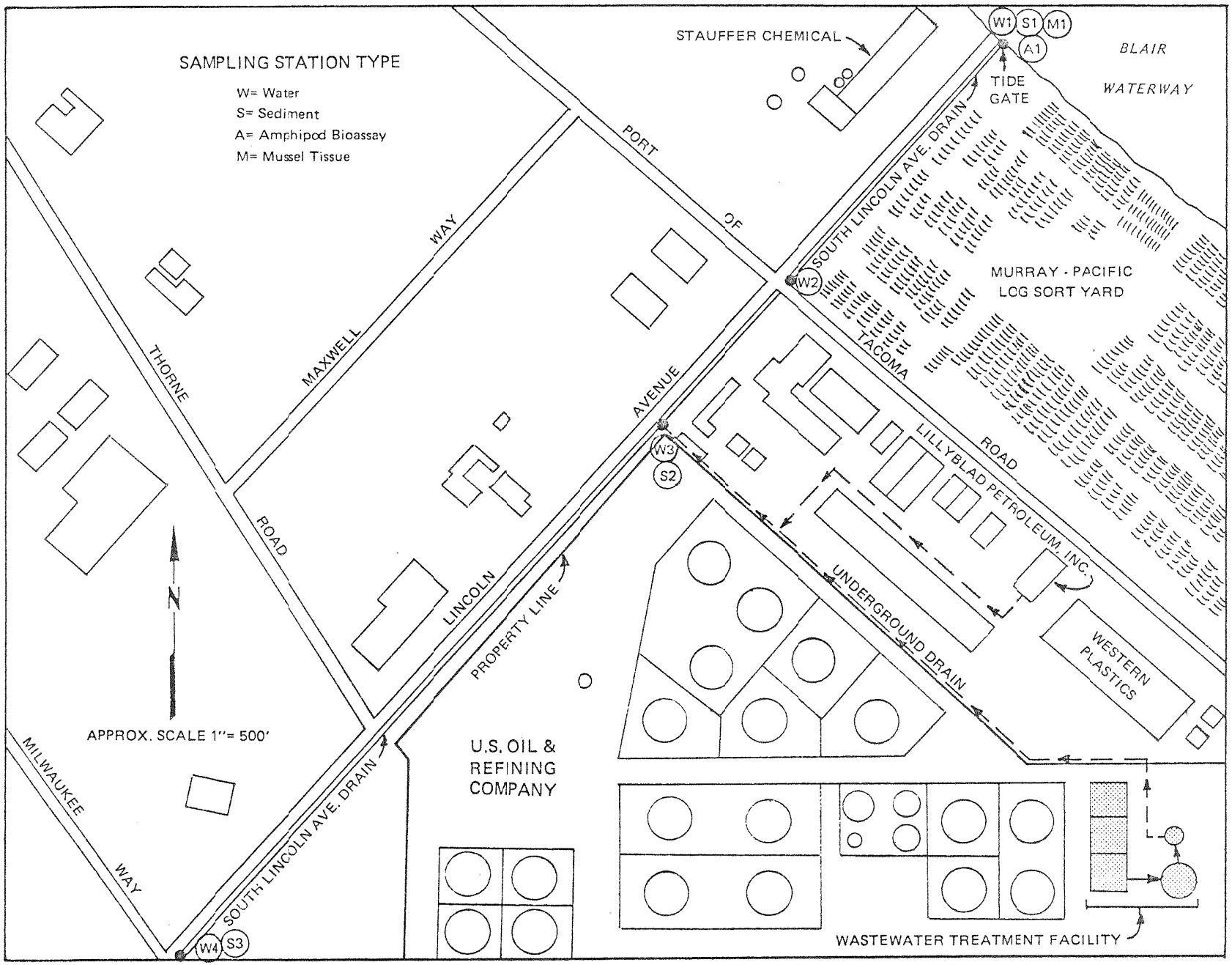

FIGURE 2. MAP SHOWING PARTIAL LAYOUT OF U.S. OIL & REFINING COMPANY AND SAMPLING SITES INCLUDED IN DOE RECEIVING WATER SURVEY.

Table 1. Summary of water quality sampling data on conventional parameters collected by WDOE during receiving water survey associated with U.S. Oil and Refining Company, May 5, 1981.

Parameter	South Lincoln Avenue Drain near Milwaukee Road (W-1)	U.S. Oil Effluent	Lincoln Avenue Discharge (U.S. Oil and others) (W-2)	Log Sort Yard Runoff Pipe (W-3)	South Lincoln Ave. Drain at Mouth (W-4)
General					
Site Description	Open ditch	--	Sewer Discharge	Runoff pipe	Open ditch
Average width/depth (ft)	5.0/0.1	--	1.9/0.7	--	5.0/0.3
Flow (cfs/MGD)	1.0/1.5	.230	0.6/0.9	--	1.4/2.2
Time Sampled	1145	--	1215	--	1100
Field Tests					
Temperature (°C)	12.1	16.8/17.8[3,4]	17.8	12.5	15.2
pH (S.U.)	5.8	7.1/6.8[3,4]	5.9	5.8	6.7
Dissolved Oxygen (mg/L)	3.9	9.3	8.0	--	7.3
Laboratory Tests					
Time Sampled	1145-1545	1025-1025[5]	1215-1545	--	1055-1300
pH (S.U.)	7.3[1]	7.6[3,4]	7.5	7.0	7.5[1]
Turbidity (NTU)	20	35	16	--	16
Specific Conductivity (umhos/cm)	153C	790/850[3,4]	408	774	1288[2]
Salinity 22.5°C, ppt	0.75[2]	0.4	0.3	0.4	0.8
Chemical Oxygen Demand (mg/L)	6	--	65	--	49
Fecal Coliforms (col/100 ml)	10[3]	<1[3]	4[3]	--	16[3]
Nitrate-nitrogen (mg/L)	0.06	5.3	2.1	--	0.86
Nitrite-nitrogen (mg/L)	<0.C1	<.05	<0.01	--	0.01
Ammonia-nitrogen (mg/L)	2.2	.30	0.09	--	2.0
Orthophosphate-P (mg/L)	0.25	.05	0.08	--	0.37
Tctal Phosphate-P (mg/L)	0.5C	.34	0.19	--	0.41
Tctal Solids (mg/L)	1,0C0	500	280	--	820
Tctal Non-volatile Solids (mg/L)	870	420	220	--	700
Tctal Suspended Solids (mg/L)	12	24	12	--	16
T. Non-volatile Susp. Solids (mg/L)	8	6	3	--	8
Rec. Phenolics as Phenol (mg/L)	.004/.006[3,4]	.015/.013[4]	.006	--	.009/.016[3,4]
Rec. Oil and Grease (mg/L)	2/1[3,4]	7	3	--	<1/6[3,4]
Asbestos Fibers/100 ml	2	--	--	--	--

[1] Average of five grab samples.
[2] Average of four grab samples.
[3] Grab sample.
[4] Two samples collected.
[5] 24-hour composite.

Table 2. Summary of priority pollutant and other toxic substances sampling data collected from South Lincoln Avenue Drain.

Sampling Results	Water: WDOE 5/5/81 Receiving Water Data (ug/L)					Water: USEPA Historical Sampling Data (ug/L)							Sediment[g]		
	Lincoln Avenue Drain near Milwaukee Road	U.S. Oil Effluent	U.S. Oil/combined Discharge	Lincoln Avenue Drain at Mouth	Field Quality Assurance	Lincoln Ave. Drain near Milwaukee Rd. (9/24/80)	Lincoln Ave. Drain near Thorne Road (9/24/80)	Lincoln Ave. Drain near Landscape Bark (9/24/80)	Lincoln Ave. Drain near Mouth (9/24/80)		Lincoln Avenue Drain near Mouth (6/3/80)		Lincoln Avenue Drain near Milwaukee Road (5/5/81)	Lincoln Avenue Drain at U.S. Oil Outfall (5/5/81)	Wet Weight (ug/g) Lincoln Ave. Drain near Mouth (5/5/81)
Time	1145-1545	1025-1025	1020-1600	1100-1400	1030	1205	1153	1145	1135		1440				1300
Sample Type	Composite	Composite	Composite	Composite	Composite	Grab	Grab	Grab	Grab		Grab		Grab	Grab	Grab
EPA Sample Number	11J-6	11J-3	11J-5	11J-4	11J-2	--	--	--	--		--		--	--	11J-7
EPA Laboratory Number	18753	18750	18752	19751	19701	38217	33216	38215	38317		22309		--	--	18754
Laboratory Method*	GC	GC	GC	GC	GC	GC	GC	GC	GC	GC/MS	GC	GC/MS	--	--	GC
PARAMETER															
Acid Compounds															
Pentachlorophenol	12	--	3.0	3.8	--	--	--	--	--	--	--	--			--
Base-Neutral Compounds															
1,2-Dichlorobenzene	--	--	--	5.5	--	--	--	--	6+	10	--	--			52
1,4-Dichlorobenzene	--	--	0.9	1.6	--	--	--	--	--	--	--	--			18
Hexachlorobenzene	--	--	--	--	--	1.1	--	--	--	--	--	--			--
Napthalene	--	--	9.7	--	--	8.8	5.1	--	--	--	--	--			--
Acenapthylene/phenanthrene	--	--	--	--	--	2.5	2.7	--	--	--	--	--			--
Fluoranthene	--	--	--	--	--	4.8	--	--	--	--	--	--			--
Pyrene	--	--	--	--	--	6.8	--	--	--	--	--	--			--
Diethyl phthalate	--	--	--	--	--	--	--	--	--	--	--	--			--
Bis-(2 ethylhexyl)phthalate	--	--	--	--	--	--	--	--	--	2	--	--			--
Volatiles										8					9900
Chloroform	1.0	--	3.9	1.3	--	3.9	--	--	>7.6	2	>5.7	3			--
Acetone	--	--	--	--	--	--	--	--	--	--	--	500h			--
Methylene chloride	19	--	310	60	14	--	--	--	--	--	>34	25			36
Chlorodibromomethane	--	--	--	--	--	--	--	--	--	--	1.5	--			--
1,1-Dichloroethane	--	--	2.0	1.1	--	--	--	--	--	3.4	--	--			--
1,2-Dichloroethane	--	--	--	--	--	--	--	--	>3.4	1.9	a	7			--
1,1,1-Trichloroethane	--	--	6.0	2.4	--	--	--	--	>3.7	6	>18	60			--
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--	--	2.3	--	--			--
1,2-Trans-dichloroethylene	--	--	1.1	0.7	--	--	--	--	--	1.4	a	--			--
Trichloroethylene	--	--	--	--	--	2.7	--	--	--	0.5	>4.4	1			--
Tetrachloroethylene	--	--	2.2	--	--	--	--	--	>2.1	0.6	--	6			--
Benzene	--	--	--	--	--	--	--	--	--	--	1260	--			--
Chlorobenzene	--	--	--	--	--	--	--	--	--	7.1	--	--			--
Toluene	--	--	1.1	--	--	--	--	--	--	0.6	4	--			--
Hexachloroethane	--	--	--	--	--	--	--	--	--	--	a	--			--
Methyl ethyl ketone	--	--	--	--	--	--	--	--	--	--	--	65h			--

Table 2. Continued.

Pesticides														
Aldrin	0.1a	--	0.4a	0.4a	--				--					--
Alpha BHC	--	--	--	a,b	--				<.005e					a,c
Gamma BHC (lindane)	--	--	--	--	--				<.005e					a,c
4,4' DDT	--	--	--	--	--				.002e					--
4,4' DDE	--	--	--	--	--				.005e					--
4,4' DDD	--	--	--	--	--				.016e					--
Toxaphene	--	--	--	--	--				<.10e					--
PCB (1242)	--	--	--	--	--				<.05e					--
Other PCBs	--	--	--	--	--				<.05e					--
Tentatively Identified Compounds														
Hexadecanoic acid	d	d	--	--	--									d
2-Ethyl hexanoic acid	--	--	d	--	--									--
Tetradecanoic acid	--	--	--	--	--									d
1H-Indene	--	--	d	--	--									--
Metals[f]														
Lead	<14	15	<14	<14	<14	90	95	15	8		35		340	22	210
Cadmium	<5	<2	<5	<5	<5	1.6	1.4	.5	<.2		.2		6.3	0.68	1.5
Copper	8	<10	5	7	<1	68	87	12	14		21		850	22	200
Beryllium						<.3	<.3	<.3	<.3		.2		--	--	--
Silver						<.4	<.4	<.4	<.4		.25		--	--	--
Thallium						<3	<3	<3	3		1		--	--	--
Selenium						<2	<2	<2	<2		2		--	--	--
Antimony						<2	<2	<2	<2		8		--	--	--
Arsenic	5	<16	<16	46	<16	154	752	283	60		75		890	<5	530
Zinc	60	125	70	50	<10	160	530	<20	40		85		740	150	400
Chromium	<10	45	<10	<10	<10	12	20	7	12		43		150	12	53
Nickel	<50	<10	<50	<50	<50	14	29	11	12		22		89	12	24
Mercury	<.2	.45	<.2	<.2	<.2	1.6	2.9	.35	.21		.45		7.8	0.14	0.43
Manganese											480				
Other															
Cyanide	<5	--	--	<5	<5	--	--	--	--	--	--	--	--	--	--

* = Organics only.
-- = Analyzed for but not detected.
a = Value not confirmed.
b = Less than 1 microgram per liter.
c = Less than 25 micrograms per liter.
d = Tentative identification, no quantitative estimates were made.
e = GC/EC analysis.
f = WDOE and EPA both use atomatic spectrophotometry or graphite furance depending on analytical sensitivity needed.
g = Sediment metals are mg/Kg dry weight while sediment organics are wet weight.
h = Identification based solely on USEPA/National Institute of Health, Mass Spectro Search System.

Table 3. Summary of USEPA water quality criteria for chemical compounds observed in surface waters near U.S. Oil and Refining Company.

Parameter	Freshwater (µg/L) Not to Exceed: Anytime	24-hr. Average	Acute	Chronic	Saltwater (µg/L) Not to Exceed: Anytime	24-hr. Average	Acute	Chronic
Acid Compounds								
Pentachlorophenol	--	--	55	3.2	--	--	53	34
Base-Neutral Compounds								
1,2-Dichlorobenzene	--	--	1,120	763	--	--	1,970	--
1,4-Dichlorobenzene	--	--	1,120	763	--	--	1,970	--
Hexachlorobenzene	--	--	250	50	--	--	160	129
Napthalene	--	--	2,300	620	--	--	2,350	--
Acenapthylene/phenanthrene	--	--	1,700	520	--	--	970	500
Fluoranthene	--	--	3,980	--	--	--	40	16
Pyrene	--	--	--	--	--	--	300	--
Diethyl phthalate	--	--	940	3	--	--	2,944	3.4
Bis-(2 ethylhexyl)phthalate	--	--	940	3	--	--	2,944	3.4
Volatiles								
Chloroform	--	--	28,900	1,240	--	--	--	--
Acetone	--	--	--	--	--	--	--	--
Methylene chloride	--	--	--	--	--	--	--	--
Chlorodibromomethane	--	--	--	--	--	--	--	--
1,1-Dichloroethane	--	--	--	--	--	--	--	--
1,2-Dichloroethane	--	--	118,000	20,000	--	--	113,000	--
1,1,1-Trichloroethane	--	--	--	--	--	--	31,200	--
1,1,2,2-Tetrachloroethane	--	--	--	2,400	--	--	9,020	--
1,2-Trans-dichloroethylene	--	--	11,600	--	--	--	224,000	--
Trichloroethylene	--	--	45,000	21,900	--	--	2,000	--
Tetrachloroethylene	--	--	5,280	840	--	--	10,200	450
Benzene	--	--	5,300	--	--	--	5,100	700
Chlorobenzene	--	--	250	50	--	--	160	129
Toluene	--	--	17,500	--	--	--	6,300	5,000
Hexachloroethane	--	--	980	540	--	--	940	--
Methyl ethyl ketone	--	--	--	--	--	--	--	--
Pesticides								
Aldrin	3.0	--	--	--	1.3	--	--	--
Alpha BHC	--	--	100	--	--	--	0.34	--
Gamma BHC-(lindane)	2.0	.080	--	--	0.16	--	--	--
4,4' DDT	1.1	.001	--	--	0.13	.001	--	--
4,4' DDE	--	--	1,050	--	--	--	14	--
4,4' DDD	--	--	0.6	--	--	--	3.6	--
Toxaphene	1.6	.013	--	--	.070	--	--	--
PCB (1242)	--	.014	2.0	--	--	.030	10	--
Other PCBs	--	.014	2.0	--	--	.030	10	--
Tentatively Identified Compounds								
Hexadecanoic acid	--	--	--	--	--	--	--	--
2-Ethyl hexanoic acid	--	--	--	--	--	--	--	--
Tetradecanoic acid	--	--	--	--	--	--	--	--
1H-Indene	--	--	--	--	--	--	--	--
Metals*								
Lead	74	0.75	--	--	--	--	668	25
Cadmium	1.5	.012	--	--	59	4.5	--	--
Copper	12	5.6	--	--	23	4.0	--	--
Beryllium	--	--	130	5.3	--	--	--	--
Silver	1.2	--	--	0.12	2.3	--	--	--
Thallium	--	--	1,400	40	--	--	2,130	--
Selenium	260	35	--	--	410	54	--	--
Antimony	--	--	9,000	1,600	--	--	--	--
Arsenic (trivalent inorganic)	440	--	--	40	--	--	508	--
Zinc	180	47	--	--	170	58	--	--
Chromium	2,200	--	--	44	--	--	10,300	--
Nickel	1,100	56	--	--	140	7.1	--	--
Mercury	.0017	.00057	--	--	3.7	.025	--	--
Manganese	--	--	--	--	--	--	--	--
Other								
Cyanide	52	3.5	--	--	--	--	30	2.0

*Based on a hardness of 50 mg/L as $CaCO_3$.

Table 5. Summary of recent trace metals data collected on the edible bay mussel (*Mytilus edulis*) in Puget Sound.

Study	Date Sampled	Metal (µg/g) (dry weight) Copper	Zinc	Nickel	Chromium	Cadmium	Lead	Mercury	Arsenic
Present Effort									
Blair WW, off Lincoln Dr. S.	5/5/81	13	330	2.7	1.6	2.3	<5.0	0.015	19
Bernhardt (1982)									
Embayment, Lincoln Ave. Dr. N.	5/5/81	13	450	5.1	1.5	2.8	<5.0	0.097	56
Olsen and Schell (1977)									
Puget Sound & Hood Canal	--	7.4[1] / 4.9-12.6	169.7 / 77.9-317	-- / --	6.4 / 0.93-11.9	3.7 / 2.8-5.5	6.6 / 2.5-14.8	.109 / .016-.130	-- / --
Price (1978)[2]									
Lower Puget Sound	6,7,8/77	9.7[3] / 4.8-90.9	309.1 / 84.2-969.7	-- / --	-- / --	9.7 / 3.0-17.0	18.2 / 5.4-34.5	.194 / .017-1.3	43.6 / 18.8-72.7
Commencement Bay									
Browns Point	--	--	303.0	--	--	--	13.3	0.37	45.4
Hylebos Mouth	--	11.0	969.7	--	--	3.9	26.8	0.19	44.8
S.W. Shore, Com. Bay	--	25.4	369.7	--	--	17.0	34.5	0.29	60.6
ASARCO, S.E.	--	90.9	545.5	--	--	10.3	33.9	1.03	54.5
ASARCO, N.W.	--	24.2	848.5	--	--	12.1	30.3	0.36	72.7
Cloud (1979)[2]									
Near ASARCO (WDOE Lab)	9/20/78	297.0	472.7	<30	<6	7.9	35.2	--	4.6
Near ASARCO (ASARCO Lab)	9/20/78	407.9	407.9	--	--	4.6	29.7	--	15.8
Heffner (1981)									
Near ASARCO (WDOE Lab)	2/24-25/81	135	533	1.4	1.7	2.95	.89	--	16.2
Near ASARCO (ASARCO Lab)	2/24-25/81	278	642	<4.7	9.4	8.9	51.9	--	10.7
Nr. Hartstene Is. (WDOE Lab)	2/24-25/81	11	162	2.7	1.5	5.0	1.01	--	1.70
BWMP Stations[4]									
Dabob Bay	9/6/79	18	261	4.0	2.1	17.0	1.36	--	2.61
Dabob Bay	8/25/80	12	223	1.3	.99	10.5	1.77	--	1.04
Port Susan	7/9/80	6	81	1.4	.86	3.57	1.86	--	.98
Carr Inlet	7/10/80	7	148	.78	.82	5.92	1.33	--	.77
Case Inlet	7/9/80	7	141	1.1	.72	6.34	1.23	--	1.65

[1] 7.4 / 4.9-12.6 = mean / range

[2] Reported as µg/g wet weight; converted to dry weight using .165 dry/wet ratio used by Olsen and Schell (1977).

[3] 9.7 / 4.8-7.3 = median / range

[4] BWMP = Basic Water Monitoring Stations sampled by Department of Ecology (WDOE).

Table 6. Loadings for Lincoln Drain South based on May 5, 1981 sampling performed by the Department of Ecology.*

Parameter	Lincoln Drain at Milwaukee Rd. (lbs/day)	U.S. Oil Effluent (lbs/day)	U.S. Oil/ combined Discharge (lbs/day)	Lincoln Drain at Mouth (lbs/day)
Flow (cfs)	1.013	.230	.577	1.359
Organics				
Recoverable Phenolics as Phenol	.02, .03	.029, .025	.019	.094
Recoverable Oil and Grease	10.9, 5.5	13	9.72	<26.4
Pentachlorophenol	.066	ND	.010	.029
1,2-Dichlorobenzene	ND	ND	ND	.042
1,4-Dichlorobenzene	ND	ND	.003	.012
Napthalene	ND	ND	.031	ND
Chloroform	.005	ND	.013	.010
Methylene chloride	.104	ND	1.004	.454
1,1-Dichloroethane	ND	ND	.006	.008
1,1,1-Trichloroethane	ND	ND	.019	.018
1,2-Trans-dichloroethylene	ND	ND	.004	.005
Tetrachloroethylene	ND	ND	.007	ND
Toluene	ND	ND	.004	ND
Metals				
Lead	<.08	.02	<.04	<.10
Cadmium	<.03	<.002	<.02	<.04
Copper	.04	.01	.02	<.01
Arsenic	.03	<.02	<.05	<.12
Zinc	.33	.16	.22	<.07
Chromium	<.05	.06	<.03	<.07
Nickel	<.27	<.01	<.16	<.36
Mercury	<.001	.0005	<.001	<.001

ND = None detected.

*The loadings were calculated by the conversion: flow (cfs) x concentration (mg/L) x 5.4 = lbs/day.